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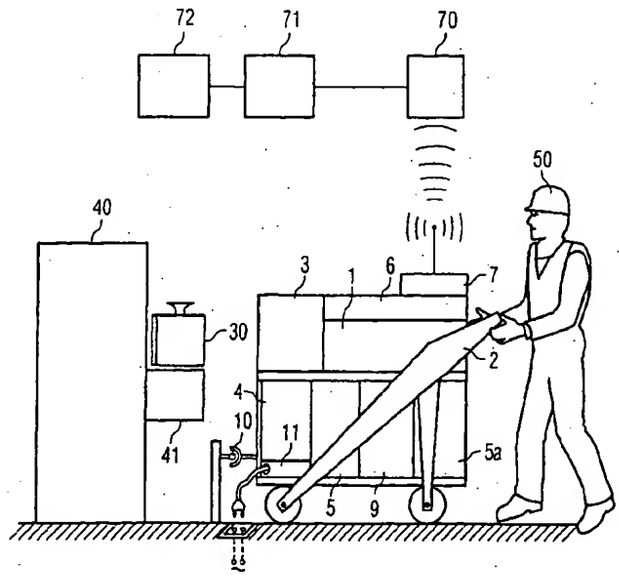
For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: MEASUREMENT ARRANGEMENT



(57) Abstract: A measurement device (1), i.e. a metrology tool, and a vehicle (2) are combined to provide a mobile metrology in a fabrication facility. Peripheral equipment such as a device transfer unit (3), for, e.g., FOUPs in semiconductor manufacturing, an electronic control system (5) with, e.g., a PC, monitor and keyboard and optionally a vacuum pump (9) is also provided in module frames of the vehicle (2). The measurement arrangement particularly reduces bottleneck situations in equipment qualifying of processing tools (40) during fast ramp-up phases of, e.g., semiconductor manufacturing facilities, thereby saving costs. The construction is based on PGVs or AGVs and allows a fast operation directly at the location of a processing tool (40). With the possible exception of power supply or operator control, the measurement arrangement can operate fully autonomous.

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Description

Measurement arrangement

The present invention relates to a measurement arrangement, for performing a measurement of at least one of a length, width, depth or position of a structure, a thickness of a film or a defect, on a plate-like object.

In the semiconductor manufacturing industry in order to retrieve an optimum Return-on-Invest (ROI) it is necessary to establish a fast ramp-up of new manufacturing facilities. Thereby, it is not only important to save costs by starting the regular production of devices as early as possible, but also to introduce new technologies to the market in a very short time. Besides the time needed to solve the logistic problems associated with a fab ramp-up, one main contributor to the ramp-up time is the equipment qualifying during ramp-up. When the test production of devices has started, these devices are inspected using various types of metrology tools, and the process tools involved are either furhter optimized in their setups or released for mass-production, when specifications are fulfilled.

In production planning performed priorily to the ramp-up phase the capacity of metrology tools is adapted to the manufacturing needs of the process tools in order to preclude non-productive equipment time, thereby saving costs. Unfortunately, since all the equipment, i.e. process tools, is to be qualified within a very short time, a larger metrology capacity is needed during the ramp-up phase than in the following production phase. Therefore, a metrology bottleneck develops during the ramp-up phase, which then inevitably will be prolonged. Thus, the Return-on-Invest is disadvantageously reduced.

In particular, metrology tools designed to inspect 300 mm semiconductor wafers have considerably increased in costs as compared with tools designed for previous wafer generations, which is due to technology costs as well as clean-room area footprint. Additionally, new metrology tools increasingly complicate the fabrication facility data flow, because due to the tightened specifications large amounts of data have to be exchanged between product specification databases, the work-in-progress system and the clusters of metrology tools. On the contrary a suitable data flow established in the manufacturing phase is not yet functional in the ramp-up phase. Furthermore these somewhat cumbersome metrology tools like ellipsometers, particle counters, optical inspection tools, overlay control systems, scanning electron microscopes, etc. provide functionality, that is not needed in the ramp-up phase.

The need for clustering of metrology tools results in large transport distances between a process tool to be qualified and the corresponding metrology tool while the advantages of the metrology tools being a part of the data transfer system and the material storage system could be renounced in the case of the ramp-up phase. The same is valid in the case of system maintenance of a single process tool during the manufacturing phase, where series of test devices are produced and immediately inspected.

It is therefore a primary objective to increase the Return-on-Invest of a semiconductor device fabrication facility during its ramp-up and manufacturing phase with respect to the metrology investment.

The objective is solved by providing a measurement arrangement, for performing a measurement of a feature of a plate-like object, comprising a measurement device for measuring said feature, in particular at least one of a length, width, depth or a position of a structure, a thickness of a film or

a defect, on said plate-like object, an electronic control system for a controlling said measurement device, a transfer unit for providing said plate-like object to said measurement device, a means for providing electrical power to said measurement arrangement, a vehicle provided with spaces each for receiving said measurement device, said electronic control system, said transfer unit and said means for providing a power supply.

The main aspect of the present invention is the combination of a measurement device and a vehicle for transporting the device. By the term measurement device a metrology tool as it is used in semiconductor industry is denoted, e.g. a particle counter, an ellipsometer for measuring the thickness of very thin films down to a few manometers, a reflectometer for measuring the thickness of thin films being thicker than 100 nm e.g. photo resists. The measurement device, or metrology tool, can also be a Fourier transform spectrometer for measuring the thickness particularly of epitaxial films or the concentration of dopants like Boron or contaminations like carbon. Alternatively, it can be a system for measuring the critical dimensions of a semiconductor structures, using optical, scanning electron or other types of microscopes. The measurement device may also be considered to be an overlay control tool measuring the position accuracy of structures, a defect inspection tool or a tool measuring the depth profiles of structures, e.g. scanning electron microscopes (SEM) or atomic force microscopes (AFM).

Modern developments of such metrology tools, e.g. especially in the case of ellipsometers, enable compact and portable configurations for metrology tools having a weight of some tens of kilograms, which is to be compared with some hundreds of kilograms inferred from conventional stand-alone measurement devices. According to the present invention these compact metrology tools are preferrably combined with vehicles, which comprise wheels and a chassis being stable to carry the

metrology tool and its peripherals. Preferably the vehicle is a personal guided vehicle (PGV) or an automatic guided vehicle (AGV), which have a structure based on similar vehicles used in cleanroom areas for transporting wafer carriers.

The vehicle comprises at least one of shelves, slide-in units or other plug-in options for receiving the metrology tool and its peripherals. It is therefore adapted in its form to carry the weight and the volume of said equipment. The inserted equipment accordingly is fixed, mounted or just placed and held by gravity inside the vehicle module frames. The vehicle can be guided by an operator or, as in the case of AGVs, be driven by an electric motor, a sensor and a control unit for detecting the position and controlling the movement.

The arrangement additionally comprises peripherals necessary to perform a metrological measurement of plate-like objects with the measurement device. One of them is a transfer unit, by which a plate-like object is introduced to the metrology tool on the vehicle. In the case of the plate-like object being a semiconductor wafer, the transfer unit preferably is asscociated with a carrier plate provided with pins to accurately place and position a wafer carrier on the vehicle in front of the metrology tool. In this preferred configuration an electrically-driven mechanical means transfers the wafer into the metrology tool, i.e. a automatic wafer handling system.

The plate-like objects are considered to be at least one of semiconductor wafers, masks or reticles, flat panels, photovoltaic devices, hard disks, DVDs, CD-ROMs, optical data storage means or the like. The exact transfer unit configuration may vary from type to type of the plate-like object.

Another peripheral necessary for performing a measurement is the means for providing electrical power. This may be established by at least one of a mains power supply, an on-vehicle

accumulator or on-vehicle batteries. In the first two cases the vehicle comprises an electric plug, which can be connected to an external connector.

The measurement arrangement further comprises an electronic control system, which controls the sequence of steps, the system parameters and the peripheral equipment for performing the measurement. In a preferred embodiment the electronic control system comprises a PC with a keyboard and monitor to allow for an interaction of the measurement with an operator controlling the metrology step. The PC is connected to the metrology tool via an e.g. SECS/GEM-interface in this embodiment. The automatic handling system is also controlled by the electronic control system.

The measurement arrangement according to the present invention advantageously provides a mobile metrology system. The measurement arrangement is easily carried to the location, i.e. the process tool, where it is currently needed. In particular, during the ramp-up phase of the fabrication facility time is saved by qualifying process equipment with the present measurement arrangement, because it can be positioned directly in front of the process tool that currently under investigation (qualifying). A series of test wafers can be processed and immediately inspected by the measurement arrangement without employing a complicated material storage and transport system. Inspection results are instantaneously fed back to the process equipment operator staff, which can quickly perform the necessary actions, e.g. adjust system parameters etc.

Additionally, the measurement arrangement can be advantageously employed for system maintenance. Wafer data, e.g. are collected quickly and the maintenance phase is thus shortened. No external media are required with the exception of power supply.

Therefore, time and costs are saved by the measurement arrangement according to the present invention. The ramp-up phase of semiconductor fabrication facilities is shortened by removing the metrology bottleneck, which hitherto was inherent from stand-alone metrology tools. Since the measurement arrangement can also be used for production wafers, there is no problem with over-capacity in this phase. Moreover, the measurement arrangement could even be transported more easily to the next ramp-up facility. The Return-on-Invest is thus efficiently reduced.

A further aspect considers the plate-like object being a semiconductor wafer or mask. Corresponding manufacturing facilities typically have a considerable ramp-up phase and a complicated material and data flow structure. Moreover, current tools are characterised by high-end specifications, making corresponding stand-alone metrology tools essentially cumbersome. Thus, the present measurement arrangement becomes essentially advantageous.

In a further aspect the vehicle is considered to have a width in the range of 300 up to 1000 millimeters. The width is measured in a direction othogonal to the direction of movement and parallel to front side of a process tool, when the measurement arrangement is placed in front of said process tool for starting the crrier transfer. The length of the arrangement is typically longer than its width. This size, which is very simlar to that of conventional PGVs or AGVs guarantees advantageously a high degree of mobility in the narrow paths of typical cleanroom arrangements. The vehicle, i.e. the measurement arrangement, can fast and flexibly be carried to the process tool, where it is needed.

In a further aspect the vehicle is considered to receive a vacuum pump for supplying the chuck of the measurement device with vacuum for holding the semiconductor wafer. Since the vehicle is controlled autonomously with the exception of the

power supply, the vacuum pump is controlled by the electronic control system.

In a further aspect the vehicle is considered to comprise a drive for moving, a brake and steerable wheels. In this form, it very much like an AGV. It therefore moves autonomously along predefined paths in the fab to the location of a process tool, where it is just needed for a measurement. The position of such a vehicle can be controlled via inductive loops connected to a control unit. The control unit then organizes the necessary steps by managing the drive or the brakes and by steering the wheels in order to reach the destined location, e.g. a process tool.

In a further aspect the use of an accumulator for electrical power supply is considered. This feature advantageously enhances the mobility of the measurement arrangement, because no manual power connection provided by an operator is necessary, then. Moreover, the arrangement is not dependent on the existence of a free power connector in the vicinity of a measurement loaction.

In a further aspect the establishment of a mini-environment is considered. It comprises a filter system inside the metrology tool for preserving advanced cleanroom conditions inside the metrology tool and the wafer transfer area. A laminar air-flow is also provided.

In a further aspect a docking/undocking interface for a wafer carrier to the metrology tool is considered. The interface preserves the mini-environment conditions inside the wafer carrier and other metrology tools, which is accomplished by completely enclosing the inner area of the docked system from the outside area.

In a further aspect an interface for opening or closing the wafer carrier door as being part of the mini-environment is

considered. Having docked the wafer carrier to the metrology tool preserving the mini-environment conditions the wafer carrier door can be opened and the automatic handling system can load the wafer to the metrology tool. In a still further aspect the docking/undocking interface is considered to comprise a driving means accurately controlling the docking procedure.

In a further aspect the vehicle is considered to comprise a space for receiving a printer being connected to the electronic control system for documenting the measurement.

In a further aspect the measurement arrangement is considered to comprise a data transfer unit for connecting the electronic control system to a factory-wide communication system, which typically comprises access to the product specification data and the lot control system (work-in-progress) and resource tracking of the whole facility. This feature will become essentially advantageous, if the measurement arrangement is applied to production wafers in the usual manufacturing phase. The data transfer unit can comprise a cable connection unit, which can be connected to a local connector at a process tool, where the measurement arrangement is currently employed. In a still further aspect the data transfer unit is considered to comprise a means to transfer the data via a wireless communications channel. This feature advantageously renders laborious cable connecting unnecessary. Depending on the surrounding process equipment and the cleanroom specifications the data transfer can be performed in infrared light, ultrasonic or on radio frequencies.

In a further aspect the vehicle is considered to comprise vibration damping means for preventing the measurement device from vibration being transmitted by the vehicle. This is essentially important during a measurement, and the material and configuration used depends on the frequencies of the mechanically disturbing oscillation that is wished to be absor-

bed. One example implementation is to position a granite plate upon rubber material, which is mounted on the chassis of the vehicle. Also pneumatic cylinders and the like can be used to absorb vibration. The granite plate is not necessarily needed.

In a further aspect a means is considered, to which the vehicle can dock at a location in front of a process tool or at other suitable locations in a fabrication facility. This prevents the vehicle from rolling away if it is accidentally hit, e.g. by an operator. Moreover, the corresponding external docking means marks a predefined location for a vehicle, where it does not disturb other manufacturing processes and cleanroom area traffic.

In a further aspect the weight of the vehicle carrying the equipment and its peripherals is considered to be in the range of 20 kg to 50 kg. Vehicles having such a weight can be easily controlled by electric motors suitable for cleanroom areas or operator staff. A typical weight of a preferred measurement arrangement is about 100 kg.

In a further aspect a means for controlling the mini-environment during power-off state is considered. The means comprises a sensor for detecting missing power supply and immediately stops the air-cycle inside the mini-environment with the laminar air stream. Also, any connection of the air cycle system to the space outside the metrology tool is closed. This preserves the diffusion of contaminating particles into the mini-environment.

In a further aspect the vehicle is considered to comprise at least one rollers for easily moving the vehicle from one location to another. Cleanroom specific materials are preferably used for the rollers.

In a further aspect a method for performing a measurement of a feature of a plate-like object using the measurement arrangement is considered. It comprises the steps of moving the measurement arrangement from a first location to the location in front of a loadport of a process tool, loading said plate-like object from the loadport of said process tool to said measuring device using the wafer carrier, performing the measurement on said plate-like object without a phyiscal connection with the exception of at least one of electrical power supply, wireless data transfer or docking connection with the surroundings, unloading said plate-like object from the measuring device using the wafer carrier, moving said measurement arrangement to a third location

The invention is now described with reference to an embodiment taken in conjunction with the accompanying drawings, wherein

Figure 1 shows an embodiment of the measurement arrangement, carried by an operator to a docking position in front of a process tool.

Figure 2 shows a side view of the measurement device according to an embodiment with a mini-environment in a status of no power connection (a), and having a laminar air-flow during power connection (b).

Figure 3 shows a vehicle according to the present invention with a measurement device positioned on vibration-damping means.

Figure 4 shows a door-opening mechanism according to an embodiment of the present invention, prior to door-opening (a), and after door opening (b) using a lever mechanism.

Figure 5 shows the wafer carrier docking mechanism according to an embodiment of the present invention using a lever prior to docking (a), and having docked (b).

A vehicle with a chassis and a set of four wheels has a basic structure similar to a personal-guided vehicle (PGV) for transporting wafer carriers. The vehicle according to the embodiment of the present invention as shown in figure 1 comprises a module frame with several spaces for receiving slide-in units. These are an ellipsometer 1 for measuring a film thickness of a semiconductor wafer, a transfer unit 3 which comprises a space for receiving a wafer carrier 30, which is a front-opening-unified pod (FOUP), a means for providing a mini-environment inside said wafer carrier 30 and the measurement device 1, i.e. said elipsometer, a wireless data transfer unit 7, a printer 4, an electronic control system including a personal computer, connected to a keyboard and monitor 5a, a vacuum pump 9 for supplying the vacuum chuck inside the elipsometer 1, and a mains power supply 11. A dokking means 10 is mounted on the vehicle chassis 2, which can be docked to a corresponding docking means mounted to the cleanroom floor in front of a process tool 40 for bringing the measurement arrangement into a predefined position in front of a loadport 41 of said process tool 40.

In figure 1 an application of an embodiment of the measurement arrangement according to the present invention is shown in a situation of typical utilization, e.g. system maintenance, where an operator 50 is about to dock to a docking means 10 and its counterpart on the clean room floor for starting a set of measurements of semiconductor wafers which have been processed in process tool 40, a number of which is transferred to wafer carrier 30, i.e. a FOUP (front opening unified pod). The next step to be performed by the operator 50 is to provide power supply to the equipment mounted on the vehicle 2 by connecting the plug-in of the mains power supply to a connector provided in the cleanroom floor beneath the clean-

room floor docking means. In this representative situation the semiconductor wafers to be inspected are not forwarded by a factory-wide material transport system, because the process tool 40 is in a situation of system maintenance and several test wafers have to be inspected in a short time, while few data have to be exchanged with the factory-wide communication system 71.

The operator 50 then transfers the wafer carrier 30 from the loadport 41 of the process tool 40 to the transfer unit 3 of the measurement arrangement. From there a first semiconductor wafer is automatically loaded to the ellipsometer 1. A low density of contaminating is preserved by the means for providing a mini-environment 6 inside the ellipsometer 1, which is shown in figure 2. Prior to being docked by the means for docking the vehicle 10 the measurement arrangement has no power connection, such that particles could enter the wafer transfer area 1b and the sensor area 1a of the elipsometer 1 through the open slides of the slide area 6b, which is part of the air cycle system of the means for providing a mini-environment 6, because there is no laminar air flow through and out off the sensor area 1a and wafer transfer area 1b without power. To circumvent this, the means for providing a mini-environment 6 comprises a sensor for detecting electrical power and a set of small slide walls for closing the sensor area 1a and wafer transfer area 1b, if no power supply is detected, which is shown in figure 2a.

If the elipsometer 1 and the means for providing a mini-environment is connected to power the sensor forwards an associated signal to the electronic control system which then opens immediately the set of slide walls of the slide area 6b. At the same time the laminar air flow through the filter area 6a, the wafer transfer area 1b, the sensor area 1a and the slide area 6b starts to cycle, as can be seen in figure 2b.

In figure 3 it is shown that the ellipsometer 1 comprising the sensor area 1a and wafer transfer area 1b is prevented from vibration transferred through the wheels and chassis of the vehicle 2 through a set of rubbers 15, on which the ellipsometer 1 rests. The vibrations may originate from other operators walking on the cleanroom floor in the vicinity of the measurement arrangement.

The way of preserving a low density of contaminating particles inside the ellipsometer 1 and the wafer carrier 30 is shown in figure 4 in greater detail. In figure 4a a wafer carrier 30 is seen to have docked to the docking means 28 of an ellipsometer 1, or the means for providing a mini-environment 6, respectively. The ellipsometer door 25, likewise comprising the door opener for the wafer carrier door is shown to be in a closed position. Operating the lever 20b into a down-position, the door opener 25 connects to the wafer carrier door 31, unlocks it and both doors are removed from their position, thereby giving the automatic handling system free passage to unload a wafer from the wafer carrier 30 and transferring it to the wafer transfer area 1b and the sensor area 1a, which is shown in figure 4b.

The docking means 28 of the means for providing a mini-environment 6 provides a hermetic enclosement of the connected sensor area 1a, wafer transfer area 1b and the inner volume of the wafer carrier 30. In figure 5 it is shown how a wafer carrier 30, that is placed on kinematical pins 27 of a wafer carrier plate 26, can be docked to the docking means 28 by means of a lever 20a. In figure 5a a situation prior to docking is illustrated, while in figure 5b the lever 20a is lifted by which the carrier plate 26 with the wafer carrier 30 is moved towards the docking means 28 until the wafer carrier docks to the docking means. A sensor can detect this connection and signals a locking of this connection.

Data needed from a product or work in progress database 72 in order to perform a film thickness measurement can be retrieved from a sender or receiver unit of the factory-wide communication system 70 by a wireless infrared communication channel. Data transfer unit 7 transmits or receives the signals to the electronic control system 5. After the measurement corresponding data or work-in-progress transactions can be sent back to the sender or receiver 70, which transfers the information to the CIM system (computer-integrated manufacturing).

List of reference numerals

1	measuring device, ellipsometer
1a	sensor area
1b	wafer transfer area
2	vehicle
3	transfer unit
4	printer
5	electronic control system
5a	keyboard and monitor
6	means for providing mini-environment
6a	filter unit
6b	slide area
7	data transfer unit
9	vacuum pump
10	means for docking a vehicle
11	means for providing power supply, mains power supply
15	vibration damping means
20b	lever for docking wafer carrier to measurement device
20b	lever for opening wafer carrier door
25	door opener for wafer carrier door
26	wafer carrier plate
27	pin
28	interface for docking/undocking a wafer carrier
30	wafer carrier
31	wafer carrier door
40	process tool
41	loadport
50	operator
70	sender and receiver of factory wide communication system
71	CIM-system
72	product and WIP database

Claims:

1. Measurement arrangement, for performing a measurement of a feature of a plate-like object, comprising:

- a measurement device (1) for measuring said feature, in particular at least one of a length, width, depth or position of a structure, or a thickness of a film, or a defect, on said plate-like object(1),
- an electronic control system (5) for controlling said measurement device (1),
- a transfer unit (3) for providing said plate-like object to said measurement device (1),
- a means for providing electrical power (11) to said measurement arrangement,
- a vehicle (2) for providing mobility to the arrangement, the vehicle being provided with spaces each for receiving said measurement device (1), said electronic control system (5), said transfer unit (3) and said means for providing electrical power (11).

2. Arrangement according to claim 1,
characterised in that
said plate-like object is a semiconductor wafer or mask.

3. Arrangement according to claim 2,
characterised in that
said measurement arrangement has a width of more than 300 millimeters and a width less than 1000 millimeters.

4. Arrangement according to claim 3,
characterised by
a vacuum pump (9) being connected to a chuck of the measurement device (1), which holds the semiconductor wafer, said vehicle (2) being provided with a space for receiving the vacuum pump (9).

5. Arrangement according to anyone of claims 1 to 4,

characterised by
a drive, a brake and at least one steerable wheel mounted to the vehicle 2), for providing a self-powered movement of the arrangement.

6. Arrangement according to anyone of claims 2 to 5, characterised in that said means for providing electrical power (11) to said measurement arrangement comprises an accumulator.

7. Arrangement according to anyone of claims 2 to 6, characterised by
a means for providing a mini-environment (6) comprising a filter system (6a), for reducing the density of contaminating particles surrounding said semiconductor wafer during a wafer measurement, said vehicle (2) being provided with a space for receiving the means for providing a mini-environment (6).

8. Arrangement according to claim 7, characterised in that said means for providing a mini-environment (6) comprises an interface for docking or undocking (28) a wafer carrier (30) to said measurement device (1), for preserving a low density of contaminating particles surrounding said semiconductor wafer during a wafer transfer.

9. Arrangement according to anyone of claims 7 to 8, characterised in that said means for providing a mini-environment (6) comprises an interface for opening or closing (25) a wafer carrier door (31) of said wafer carrier (30).

10. Arrangement according to anyone of claims 8 to 9, characterised in that said interface for opening or closing a wafer carrier door (25) and/or said interface for docking or undocking (28) comprise an electrical driving means.

11. Arrangement according to anyone of claims 1 to 10, characterised in that said measurement device (1) is at least one of: a defect inspection tool, an ellipsometer, a particle counter, a reflectometer, a Fourier transform spectrometer, a CD-measurement tool, an overlay measurement tool, a scanning electron microscope.

12. Arrangement according to anyone of claims 1 to 11, characterised by a printer (4) connected to the electronic control system (5), said vehicle (2) being provided with space for receiving said printer (4).

13. Arrangement according to anyone of claims 1 to 12, characterised by a data transfer unit (7) for transferring data between the electronic control system (5) and a factory wide communication system (71), said vehicle (2) being provided with space for receiving said data transfer unit (7).

14. Arrangement according to claim 13, characterised in that said data transfer unit (7) has a means to transfer the data via a wireless communication channel.

15. Arrangement according to anyone of claims 1 to 14, characterised by a set of vibration damping means (15) for preventing the measurement device (1) from vibration being transmitted by the vehicle (2).

16. Arrangement according to anyone of claims 1 to 15, characterised by a means for docking said vehicle (10) at a location in a fabrication system.

17. Arrangement according to anyone of claims 1 to 16, characterised in that the measurement arrangement has a total weight of more than 20 kg and less than 150 kg.

18. Arrangement according to anyone of claims 7 to 17, characterised in that said means for providing a mini-environment (6) comprises:
- a sliding area (6b) for providing a laminar air flow inside the measurement device,
- a sensor for detecting electrical power connection,
- a means for hermetically enclosing at least a sensor area inside the measurement device, which is connected to said sensor for detecting electrical power connection.

19. Arrangement according to anyone of claims 1 to 15, characterised in that said vehicle comprises at least one wheel for rolling the vehicle between two locations.

20. Method for performing a measurement of a feature of a plate-like object using the measurement arrangement according to claims 2 to 19, comprising the steps of:
- moving the measurement arrangement from a first location to the location in front of a loadport (41) of a process tool (40),
- loading said plate-like object from the loadport (41) of said process tool (40) to said measuring device (1) using the wafer carrier (30),
- performing the measurement on said plate-like object without a phyiscal connection with the exception of at least one of electrical power supply, wireless data transfer or docking connection with the surroundings,
- unloading said plate-like object from the measuring device (1) using the wafer carrier (30),
- moving said measurement arrangement to a third location.

FIG 1

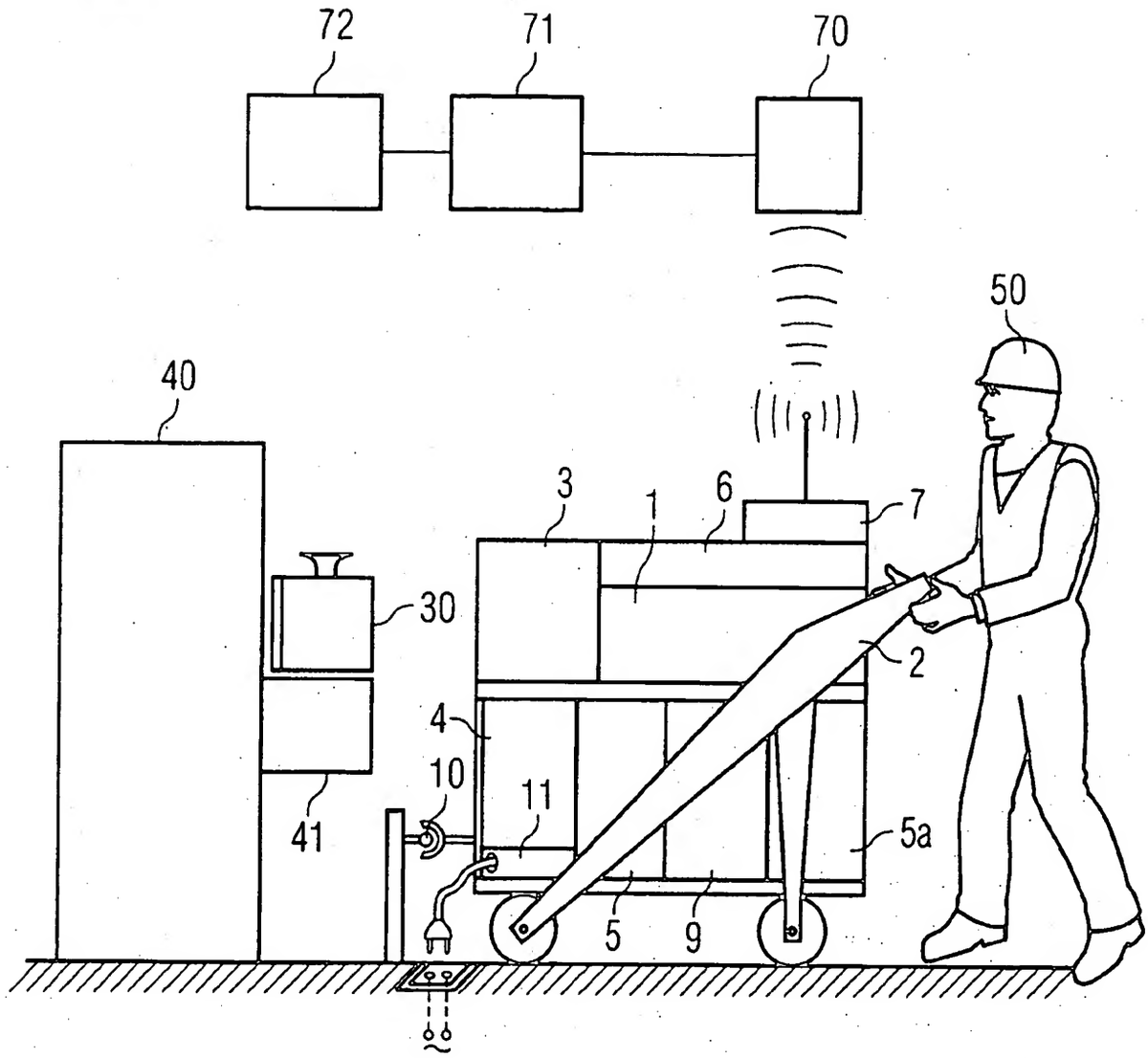


FIG 2A

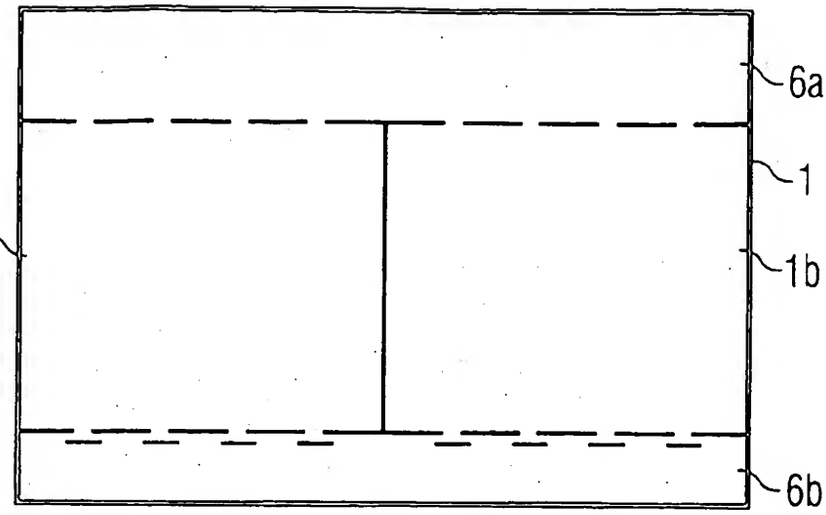


FIG 2B

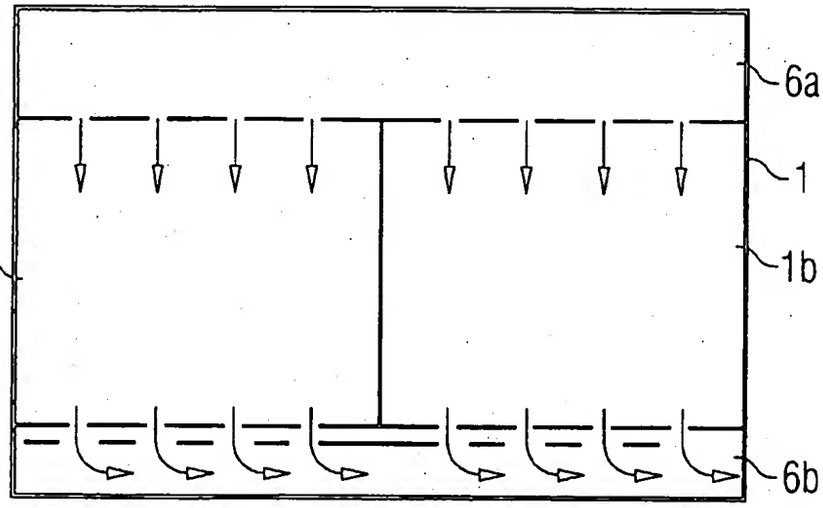


FIG 3

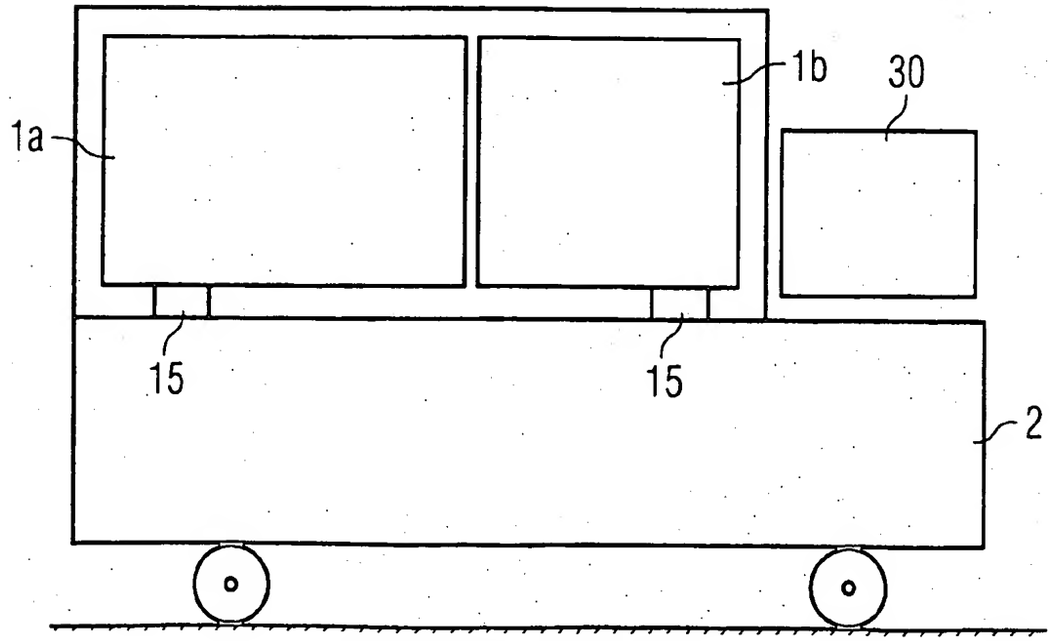


FIG 4

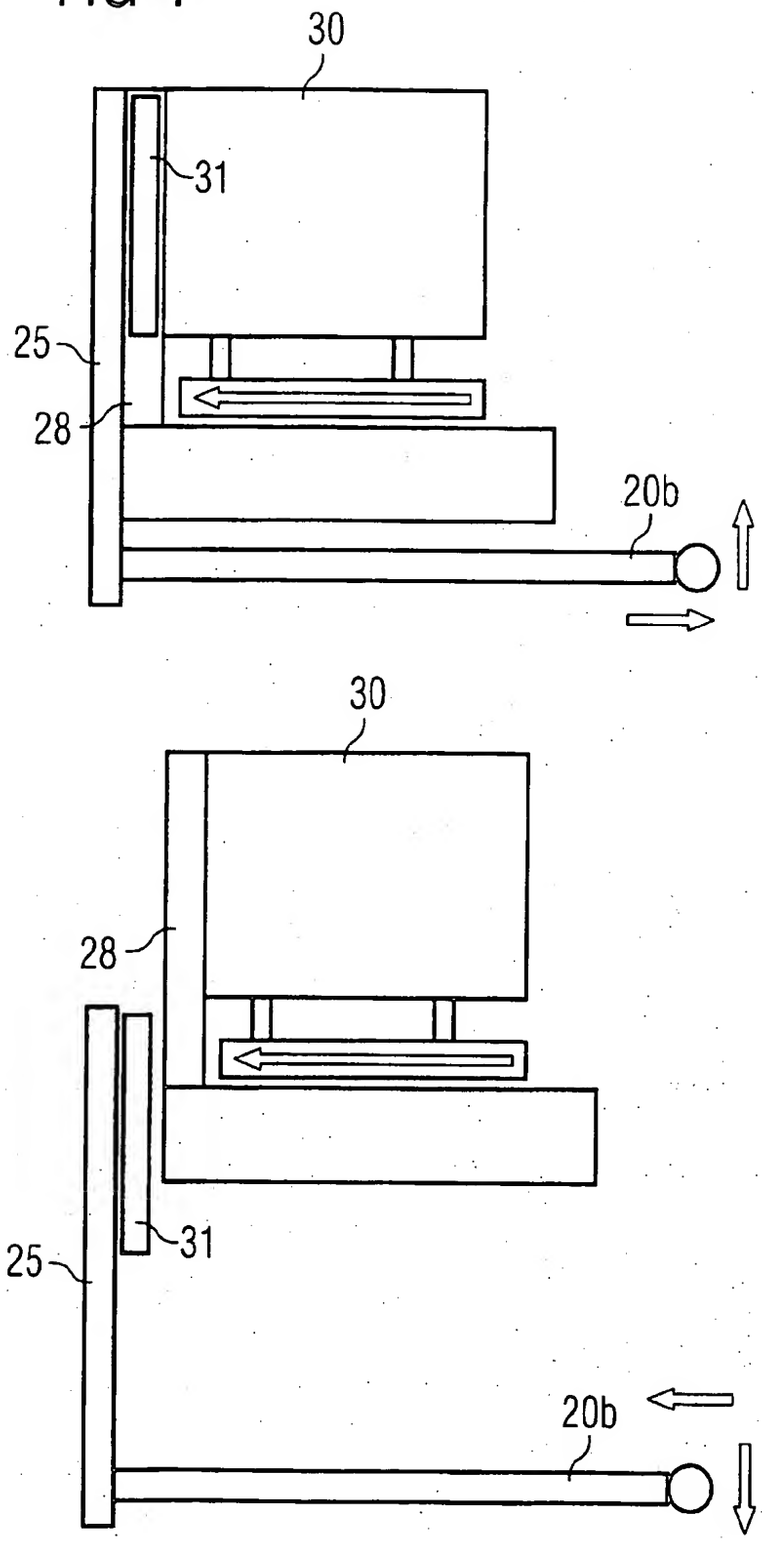
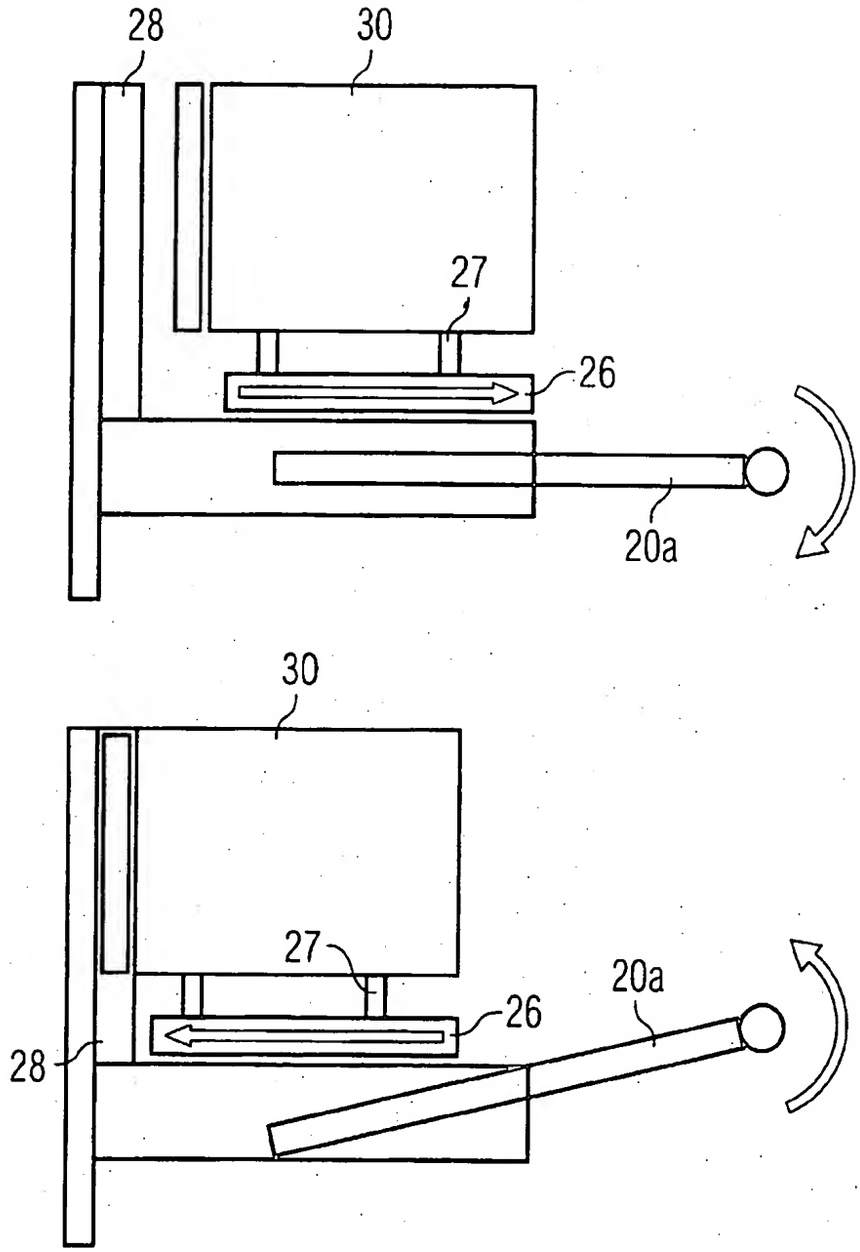


FIG 5



INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 01/15346

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H01L21/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H01L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 404 111 A (MORI ET AL.) 4 April 1995 (1995-04-04) abstract; figures 11-14 column 7, line 11-19 column 8, line 44-64 column 11, line 11-16	1,2,11, 19
Y		5,7,12, 15,16
A		4

Y	PATENT ABSTRACTS OF JAPAN vol. 1997, no. 10, 31 October 1997 (1997-10-31) -& JP 09 162262 A (TAGA SEISAKUSHO:KK), 20 June 1997 (1997-06-20)	5,7,15
A	abstract	1

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
19 April 2002	10/05/2002

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Oberle, T

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 01/15346

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	PATENT ABSTRACTS OF JAPAN vol. 013, no. 386 (E-812), 25 August 1989 (1989-08-25) -& JP 01 136346 A (NEC CORP), 29 May 1989 (1989-05-29)	12
A	abstract	1
Y	US 6 033 175 A (PFLUEGER ET AL.) 7 March 2000 (2000-03-07) column 5, line 50-67	16

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